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ONTARIO MINISTRY OF THE ENVIRONMENT  
"UPPER LIMIT OF NORMAL" CONTAMINANT  
GUIDELINES FOR PHYTOTOXICOLOGY  
SAMPLES

MARCH 1989



Environment  
Ontario

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Minister

31/03/92



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Phytotoxicology Section  
Air Resources Branch  
ARB-138-88-Phyto

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Guidelines for Phytotoxicology Samples

Background

The Phytotoxicology Section of the Air Resources Branch, in concert with associates from the Northeastern and Northwestern Regions, recognized in 1971 a need to establish contaminant concentration guidelines for interpretation of environmental data. Utilizing the results of chemical analyses and available toxicological information, guidelines which were termed "Concentrations Considered Excessive" were developed for a number of contaminants in soil and plant foliage. These guidelines were utilized in Phytotoxicology investigations, with periodic revisions as deemed appropriate, notably in 1978 and 1982.

By early 1983, it had become apparent that the processes by which the Phytotoxicology guidelines had been established to date were less than satisfactory, because they varied among contaminants, were too subjective, and could not be supported by any consistent procedure or mathematical model.

After discussion among Phytotoxicology and Regional staff, it was agreed that new guidelines should be developed which would have a consistent mathematical basis and which could be used to distinguish





contaminated from uncontaminated situations. To this end, efforts were directed toward assembling a data base of analytical results for environmental samples collected from "background" (i.e. non-point source-contaminated) areas of Ontario.

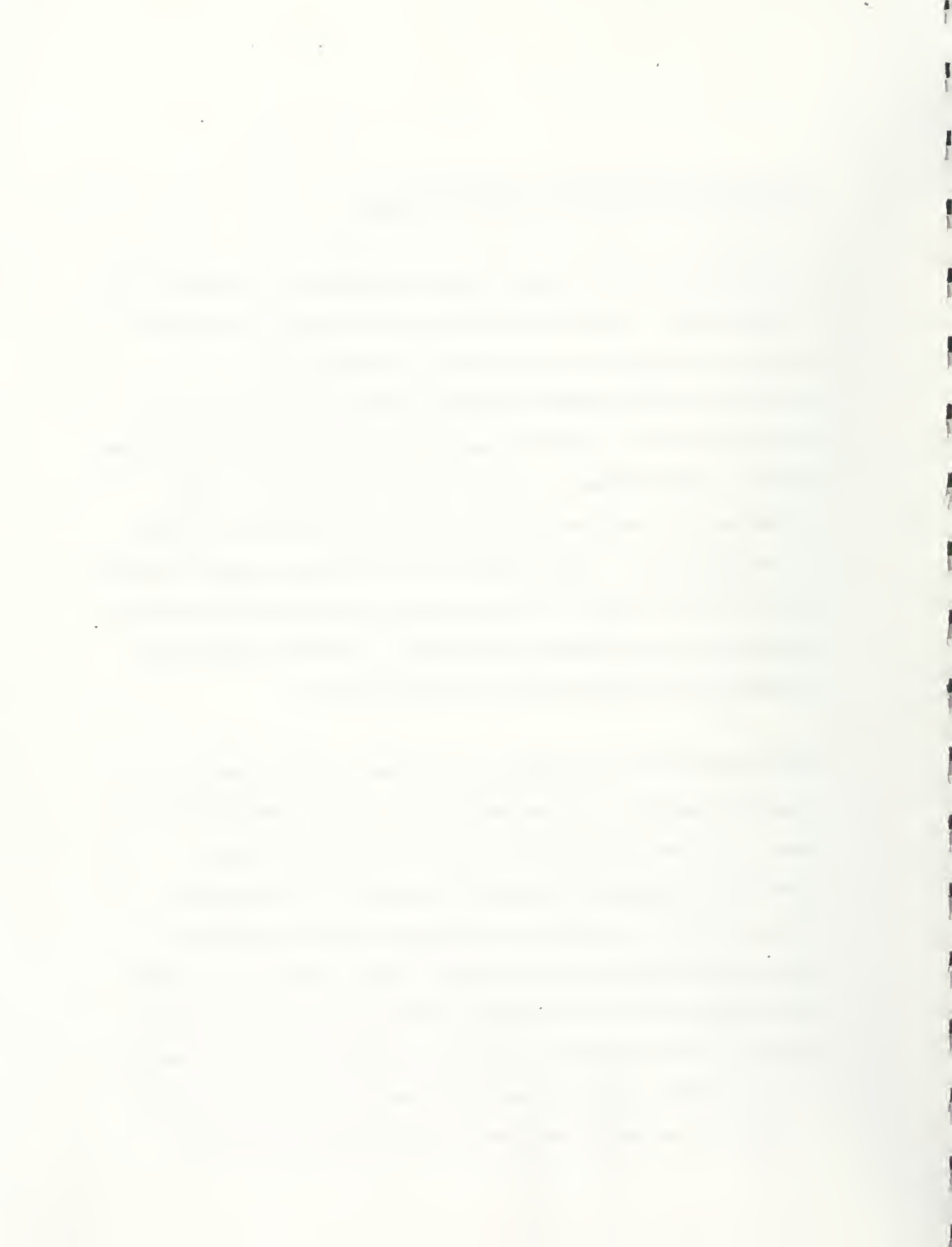
Concurrently with these developments, a large-scale review of Ontario Regulation 308 (Air Pollution - General Regulation) was initiated by the Ministry of the Environment. One of the tasks of the review was the following: "Determine if Phytotoxicology standards, criteria or guidelines should be established for soil (and vegetation) deposition. Should they be incorporated in Reg. 308, or developed into a guideline?"<sup>(1)</sup>. A committee with Air Resources Branch and Regional representatives was established to examine this issue. The committee proceeded along the lines previously initiated, and developed "Upper Limit of Normal" (ULN) contaminant guidelines for terrestrial samples collected in Ontario. The concept and philosophy of the proposed Phytotoxicology ULN guidelines were then discussed at a Reg. 308 Workshop held in Toronto in November, 1985<sup>(2)</sup>. The decision was made that the ULN guidelines, being statistically derived and subject to modification as new data are generated, not be incorporated in Reg. 308 but be published as a reference document<sup>(3)</sup>.



### Derivation and Significance of ULN Guidelines

The MOE Upper Limit of Normal contaminant guidelines are shown in the attached table. The guidelines essentially represent the expected maximum concentrations of contaminants in surface soil (non-agricultural), foliage (deciduous and current year coniferous trees and shrubs), grass, moss bags and snow from areas of Ontario not subject to the influence of point sources of emissions. "Urban" guidelines are based upon samples collected from centres of minimum 10,000 population. "Rural" guidelines are based upon samples collected from non-built-up areas. All samples were collected and processed by MOE personnel using standard techniques<sup>(4)</sup>. Chemical analyses were performed by the MOE Laboratory Services Branch<sup>(5)</sup>.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant concentration results for samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are "non-normal", the calculated upper limits of normal will not actually equal the 99th percentile; however, they lie within the observed upper range of MOE results for Ontario samples. Geometric means were not employed in calculating the guidelines



because: 1) tests of two representative non-normal distributions showed that normality was not significantly improved by using log-transformed data, and 2) the guideline concentrations calculated using the geometric mean were considerably higher than the maximum observed concentrations.

Due to the large variability in element concentrations which may be present across Ontario, even in background data, control samples should always be collected. This is particularly important for soils, which may show large regional variations in element composition due to differences in parent material. Species of vegetation which naturally accumulate high levels of an element also may be encountered and, as with soil samples, will require careful interpretation and comparison with controls to avoid erroneous conclusions regarding environmental contamination.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above-normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are



below the guidelines would not normally be considered toxic. A brief review of world literature has shown that the guideline concentrations are generally within the respective ranges of results reported by other investigators.

The table of guidelines will be expanded and revised as more data become available.

RE2754





References

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Environment.
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Pollution General Regulation Workshop, Nov. 14th/15th, 1985.
- (3) Ontario Ministry of the Environment. 1987. Stopping Air  
Pollution at its Source. Clean Air Program - Discussion Paper.
- (4) Ontario Ministry of the Environment. 1983. Field Investigation  
Manual. Phytotoxicology Section - Air Resources Branch;  
Technical Support Sections - NE and NW Regions.
- (5) Ontario Ministry of the Environment. 1983. Handbook of  
Analytical Methods for Environmental Samples, Vols. 1 & 2.  
Laboratory Services Branch.



Contaminant Guidelines Representing "Upper Limits of Normal" Concentrations (ug/g, dry weight) of Parameters in Soil, Foliage, Grass, Moss Bags and Snow in Ontario (Urban and Rural). The guidelines are approximately equal to the mean of the data plus three standard deviations.

Parameter	Soil (0-5 cm)		Foliage (unwashed)		Grass (unwashed)	Moss Bags**		Snow***
	Urban	Rural	Urban	Rural	Rural	Urban	Rural	Rural
Aluminum	a	a	500***	500	a	a	1700	0.5
Antimony	8	1**	0.5**	0.3**	a	2	a	a
Arsenic	20	10	2	0.5, 2*	c, a*	2	1	0.03
Boron	15	10**	175	75	20	a	a	a
Cadmium	4	3, 4*	2*	1*	0.5, 2*	4	2	0.003
Calcium	b	b	a	3%	a	a	a	2
Chloride	a	a	b	0.15%	1%	a	0.03%	4
Chromium	50	50	8	8	5	7	a	0.003**
Cobalt	25***	25	2***	2	2, a*	6	a	0.01**
Copper	100	60	20	20	7, 20*	60	8	0.06
Fluoride	a	a	35	15	12	a	45	0.1**
Iron	3.5***	3.5%	1000	500	500	3000	1700	0.7
Lead	500	150	60	30	20	200	35	0.05
Magnesium	a	1%	0.7%	0.7%	a	a	a	0.4
Manganese	700	700, 1000*	100	b	50, a*	a	a	0.02
Mercury	0.5	0.15	0.3	0.1	a	a	0.2	0.0001**
Molybdenum	3	2**	1.5	1.5	6	a	a	a
Nickel	60***	60	7	5, 30*	5, 25*	13	6	0.04
Nitrogen	a	a	b	b	a	a	a	3 (as nitrate)
Phosphorus	a	a	a	a	a	a	a	0.15
Potassium	a	d	a	a	a	a	a	1
Selenium	2	2	0.7	0.5	0.5	a	0.6	c
Silver	c	a	a	a	a	a	a	a
Sodium	a	a	350	50	a	a	b	2
Sulphur	a	0.1%	0.4%	0.4%	0.5%	a	0.1%	3 (as sulphate)
Vanadium	70	70	5***	5	6	a	c	a
Zinc	500	500	250***	250*	40, 100*	800	100	0.3
Alkalinity	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5.5
Conductivity	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	45
Suspended Solids	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	25
Dissolved Solids	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	30
Total Solids	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	40
Dissolved Organic Carbon	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
Dissolved Inorganic Carbon	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
Total Particulate Carbon	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	7

#### Notes:

- \* Where two values are shown, the first is based mainly on Southern Ontario data while the second is based on NE Region data. Also, there are indications that some of the guidelines, at least for foliage, may be somewhat liberal for the NW Region. THESE GUIDELINES ARE MEANT TO SUPPLEMENT, RATHER THAN REPLACE, SPECIFIC CONTROL DATA.
- \*\* Provisional guideline estimated from range of results, pending additional data.
- \*\* Rural results higher than urban results - urban guideline based on rural results.
- \* Data for species considered to be accumulators (*Populus* spp., *Salix* spp., *Betula* spp.) excluded.
- \*\* Moss bag guidelines based on 30 day exposure. No data from NE region.
- \*\*\* Snow guidelines are mg/l of meltwater, except conductivity which is  $\mu\text{hos/cm}$ . Based mainly on NW and NE Region data.
- a Sample size insufficient (<30) to establish guideline.
- b Concentration highly variable - guideline not established.
- c 50% or more of results less than detection limit - guideline not established.
- d Discrepancy between Ontario data and literature values - guideline not established.
- n.a. Not applicable (no data).









